Rapid growth of caves and speleothems: part 3—Flood and Ice Age variables

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Present-day growth rates of speleothems are around 0.1 to 2 mm/yr, but can vary from zero to more than 5 mm/yr. The variables summarized in part 2 would have been near maximized in the early-to-mid post-Flood Ice Age, producing tremendously rapid speleothem growth. They would then have decreased considerably by the end of the Ice Age. Two variables related to the end of the Flood will be discussed that would further aid the early rapid growth of speleothems. Growth could easily be over a hundred times that of today in some caves.

Uniformitarian scientists have long considered caves to be a challenge to the short timescale of Scripture. However, uniformitarians are not without their own challenges, as summarized in part 1.[1] For instance, it has recently been discovered that speleothems are much younger than they expected. Speleothems, once believed to take millions of years to grow, have been dated to be only tens of thousands to hundreds of thousands of years old by their own dating methods. Moreover, instead of taking millions of years to dissolve out a cave by carbonic acid dissolution, secular scientists have discovered strong evidence that increasingly points toward sulfuric acid having excavated most of the cave openings. Sulfuric acid is much stronger than carbonic acid and would rapidly excavate a cave, especially when combined with the uplifting of the continents relative to the ocean basins at the end of the Flood. Uplift would cause joints and faults to form, enabling acidic water to drain downward, widening joints, faults, and weak bedding planes.

In part 2,[2] the variables that determine the growth of speleothems were discussed. Growth is a complicated process that mainly depends upon five major and many minor variables. These processes, coupled with the unique climate of the post-Flood rapid Ice Age,[3,4] open up many plausible avenues for interpreting the speleothems as forming rapidly after the Flood.

Before we can consider the possibilities for speleothem growth in the early-to-mid Ice Age, we need to know the present growth rates. In part 3, I will first point out what some secular researchers believe are average growth rates along with some noteworthy above-average growth rates. Then I will estimate the effects on the variables developed in part 2 that were potentially caused by the aftermath of the Flood and post-Flood Ice Age.

Present-day growth rates

According to the literature, present-day speleothem growth rates are quite variable. This is as expected, since there are many complicated variables that contribute to the growth rate.[2] Because only a few stalagmites have annual layers or a known beginning date (i.e. a date known when a stalagmite began growing on an object placed there), researchers commonly use radiometric dating methods to determine the growth rate. The most used method, touted as very accurate, is the U-series (uranium-thorium) method. Carbon-14 is sometimes used, but since water sinks from the soil to the cave, it dissolves the carbonate, which has very little carbon-14. So, soil water carbon is mixed with what is considered the 'dead carbon'. To determine the dead carbon fraction, researchers use other methods, such as $\delta^{13}C$, but this ratio depends upon many variables, such as the ratio of C_3 to C_4 vegetation on the surface, since C_3 and C_4 vegetation have very different $\delta^{13}C$ measures.[5,6] As a result, $\delta^{13}C$ cannot be trusted to accurately determine the dead carbon fraction.

In searching the literature for growth rates, estimated growth rates that depend upon radiometric methods were avoided, since they always seem to greatly exaggerate the time. Instead, only observed growth rates were used.

Baker *et al*. determined the growth rates of various stalagmites from three caves in southern England, France, and Belgium.[7] These areas generally experience precipitation throughout the year, but with high soil evaporation in the warm season. Some stalagmite drip rates dropped to zero, while others dripped year-around, mostly with variable rates. In Brown's Folly Mine in southern England (figure 1), growth rates ranged from 0.04 to 0.16 mm/yr. This range is likely in this mine because some drips stopped while others dripped throughout the year. At Grotte de Villars, France (figure 2), growth rates were 0.55 ± 0.35 mm/yr, and at Godarville tunnel, growth rates were 0.89 ± 0.38 mm/yr. Growth rates were generally proportional to the drip Ca^{2+} concentration. One stalagmite in one of the many caves in the Rock of Gibraltar (figure 3) grew at 0.9 mm/yr.[8] Since vegetation and soil on top of a cave often determines the growth rate, there does not

Figure 1. Brown's Folly Mine, south-west England

Figure 2. Ancient drawing in the Grotto de Villars cave in south-west France

Figure 3. West face of the Rock of Gibraltar, a limestone block with numerous caves, that is 426 m (1,398 ft) high

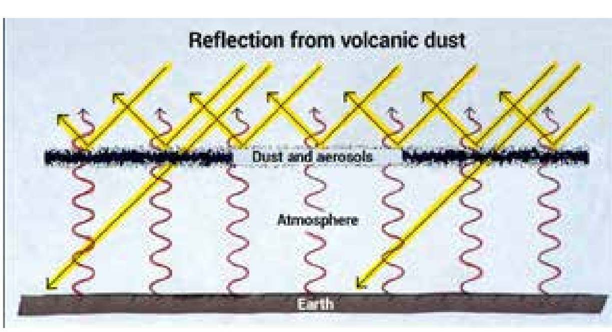

Figure 4. Schematic of some of the solar radiation reflected from volcanic ash and aerosols in the stratosphere

seem enough vegetation and soil on the Rock of Gibraltar for this growth rate. Perhaps the warmer temperatures helped. Villars Cave, south-west France, has cool summers and mild winters and some stalagmites that grow 1.0 to 1.75 mm/yr.[9] Based on annual layers, some cave stalagmites in Belgium grew up to 2.17 mm/yr, with one year at 4.3 mm/yr.[10]

Hill and Forti have concluded that the average growth rate is one or two mm/yr:

> "How fast do speleothems grow? We cannot predict a rate for a particular speleothem, but, on the average calcite travertine [on the speleothem] grows about a millimeter or two a year."[11]

However, Dreybrodt gives smaller figures, claiming that growth rates are generally several hundredths to several tenths of a mm/yr, with a maximum observed about 5 mm/yr.[12] One growth ring in a stalactite from the Altai Mountains of southern Siberia grew at 15 mm/yr, which is 50 times faster than any other ring in the stalactite.[13] No other information was given; it appears that such a rate represents very unusual circumstances. Nonetheless, this shows growth rates can be many mm/yr, even in today's climate, if the specific conditions are favourable.

Referencing Carol Hill and Paolo Forti,[14] Musgrove *et al.* published that growth rates ranged from 0.002 to 400 mm/yr.[15] Of course, the real minimum is zero, which is the case for most speleothems in Carlsbad Caverns and the many other caves of the Guadalupe Mountains.[16] Intrigued by the observation of 400 mm/yr, I checked the reference in Hill and Forti, which was from a book by Trevor Shaw: "In one instance (Southall, 1878:93) a growth rate of over 30.3 cm per year was said to have been measured and in others the rate exceeded 5 mm/yr."[17] Shaw listed 25 growth rates with an average of 3.7 mm/yr. It seems that Hill and Forti misquoted the growth rates from their source. Reading the interesting book by Southall, which challenged the so-called antiquity of man that was believed in the late 1800s, I discovered Southall did record observations of several rapid stalagmite growth rates, such as 7.3 mm/yr in a cave in Yorkshire, England.[18] It was reported that in a cave that mined lead (Pb) near Dubuque Iowa, stalactites grew about one metre in three years, which would be about 30 cm/yr,[19] as referenced by others.

However, most speleothems today are believed to be growing at the rate of less than a few mm/yr,[20] more like the estimates of Dreybrodt. Numerous articles indicate that the growth rates seem to generally lie between 0.1 and 2 mm/yr, similar to what Silvestru used to calculate the time for various speleothem growths.[1] Given this higher rate, speleothems do not need millions of years to form, which is why uniformitarian scientists now generally claim they form in tens to hundreds of thousands of years.

The Ice Age climate

Much data in the literature is consistent with a rapid excavation of caves (see part 1) and rapid deposition of speleothems, if we dismiss the uniformitarian assumption of the 'present being the key to the past' and use a global Flood and rapid post-Flood Ice Age to explain the data. To see how this works, we must understand the Ice Age climate.

The Ice Age was a result of cooler summers caused by Flood and post-Flood aerosol particles trapped in the stratosphere and a warm ocean.[3,4,21,22] After briefly describing the Ice Age, I will focus on key features of the Flood and Ice Age that result in rapid speleothem growth.

Most sulfuric acid aerosols[23] from volcanic and meteorite impacts associated with the Flood would have ended up in the stratosphere after the Flood. They would take a few dozen years to sink to the ground. The higher the aerosol rises in the stratosphere, the longer it remains there.[24] As the Flood aerosols sank, they would likely have been replaced by continuing post-Flood volcanism, which most likely continued for hundreds of years until Earth reached a near equilibrium—a climate similar to the present day. These aerosols would probably change the climate because some of the sunlight would be reflected into space, not absorbed at the surface, and would thus cool the land (figure 4). This cooling would have likely affected the summers the most. At the same time, there were processes in the ocean and atmosphere that likely resulted in warmer winters. The oceans would probably have been less affected because of their large heat capacity. Moreover, the reflectivity (albedo) on the continents would have been much higher than today because of much barren land, high reflectivity volcanic ash on barren ground, and snow, which has a much higher albedo than old and/or dirty snow (table 1).

Cool summers and warm winters are called an *equable* climate, and in many locations during the early-to-mid Ice Age the seasonal temperature changes would most likely have been slight, except over the developing ice sheets. Figure 5 shows the projected average winter, summer, and annual temperatures with time for the Northern Hemisphere mid- and high-latitude continents from the end of the Flood until today. Figure 6 shows the projected annual mid- and high-latitude Northern Hemisphere precipitation with time from the end of the Flood until today. This unique climate early in the Ice Age is indicated by the ubiquitous disharmonious associations of plants and animals in which warmer climate organisms are found in Ice Age debris with colder climate organisms.[28] The uniformitarian ice age climate model predicts a very cold winter and summer, one that is far colder than today. Disharmonious associations would be impossible in such a climate.

The oceans after the Flood would probably have been warm from surface to bottom and pole to pole. This vast amount of heat would cause immense evaporation, which

Table 1. Albedos over various surfaces in percent of solar radiation reflected back to space[25–27]

Surface	Albedo (% reflected)
Planet as a whole	~30%
Sand	18 to 28%
Grass	16 to 20%
Forests	14 to 20%
Dense forests	5 to 10%
Fresh snow	75 to 95%
Old snow	40 to 70%
Debris rich ice	6 to 30%
Debris rich firn snow	15 to 40%
Clean ice	30 to 46%

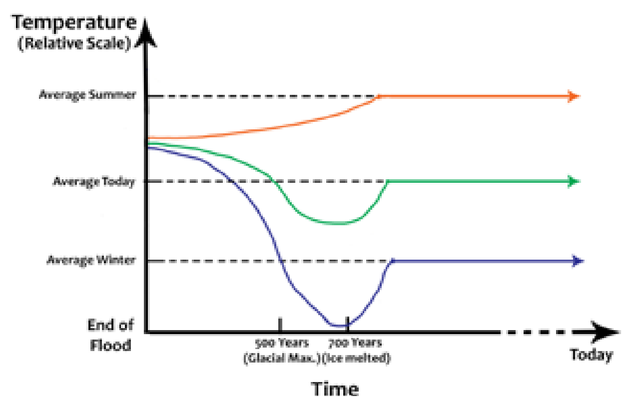

Figure 5. The average winter, summer, and annual temperature with time for the Northern Hemisphere mid- and high-latitude continents from the end of the Flood through the Ice Age to today (drawn by Melanie Richard)

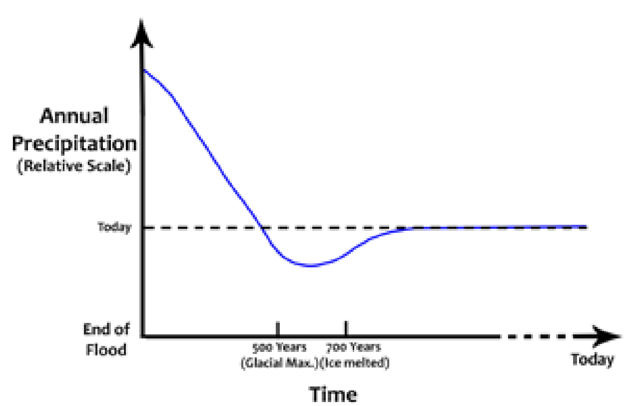

Figure 6. The annual mid- and high-latitude Northern Hemisphere precipitation with time from the end of the Flood through the Ice Age to today (drawn by Melanie Richard)

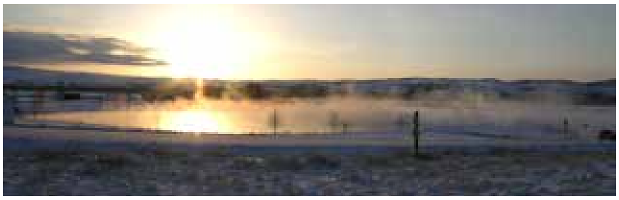

Figure 7. Steam fog from a 3-acre warm pond in early autumn near to the author's house

Figure 8. Column from Carlsbad Cavern, New Mexico

likely caused about 75% of the cooling of the oceans. The other 25% was from infrared radiation loss and by contact of cooler air with warm water. It would have been similar to what happens in the fall when cooler air flows over a pond warmed from the summer heat (figure 7). This strong oceanic evaporation would have provided the abundant snow for a rapid Ice Age with abundant rain over most of the rest of Earth. Heat liberated by the oceans would have warmed the air above the oceans. When water vapour condenses, it gives off a large amount of latent heat to the atmosphere. Thus, Ice Age winters would likely have been much warmer at mid and high latitudes early and midway through the Ice Age than today. Indeed, apart from the reflectivity of sulfuric acid aerosols, barren ground, volcanic ash on the ground, and snow cover, the warmth of the oceans would probably have swamped the summer continental cooling.[29,30,31] This unique climate is the most probable consequence of the Genesis Flood.

When we consider the Flood and the unique Ice Age climate following it, most of the variables are in place for much faster growth rates of speleothems than currently recorded. It is impossible to know exactly how much each variable would have increased speleogenesis compared to today's rates, but I will provide estimates founded on my professional training associated with my position as a weather forecaster for the National Weather Service for 30 years. These estimates (educated guesses) are used mainly to give us an idea of the significance of each variable towards growth of speleothems and are recognized as ballpark estimates.

Very high soil $CO_{2(aq)}$ and cave $Ca_{(aq)}^{2+}$

The amount of $Ca_{(aq)}^{2+}$ that drips down into the cave from the carbonate above depends strongly on the soil's $CO_{2(aq)}$,[32] and the climate would be especially important for this variable.[33] The early-to-mid post-Flood Ice Age climate would be very moist, almost everywhere. Rough calculations, based on the warm western Pacific Ocean, suggest that the semiarid south-west US would have received about four times as much precipitation as today.[34] With much more precipitation, trees and plants would grow profusely, and the soil would be thicker.[33] Since an intermediate amount of soil moisture is ideal (see part 2), the soil may have become too wet at times, retarding speleogenesis. However, in carbonate terrain, drainage should be optimal down through the joints and faults and would prevent the soil from becoming saturated, except momentarily in heavy rainstorms.

The equable early-to-mid Ice Age climate would have greatly aided the growth of soil $CO_{2(aq)}$ since photosynthesis would continue through the winters and at low-to-mid latitudes. Cooler summers would retard growth some, but in many low-to-mid latitude locations cooler summers would cause less soil evaporation, aid photosynthesis, and generate abundant soil carbon dioxide. Vegetation would flourish under these ideal conditions, so the soil's $CO_{2(aq)}$ would be very high at low-to-mid latitudes while the high latitudes were mostly covered by ice sheets. The warmer and wetter climate south of the ice would promote dense vegetation and high soil microbial activity.[35,36] Soil $CO_{2(aq)}$ could be 1.5–3 times as great from Ice Age temperature and moisture alone, especially at low latitudes and unglaciated mid-latitude locations.

Soil thickness is another variable for the formation of CO_2. After the floodwater drained, there would be areas of thick mud and vegetation in various stages of decay. This rich matrix would be ideal for re-establishing the world's flora, which in turn improved and developed the thickness of the soil. Immediately after the floodwater drained, mud would likely have high soil organic matter (SOM) from the pulverized pre-Flood biosphere. It would also tend to be thicker in *low spots* in the terrain. The SOM from the Flood would likely have lasted from decades to centuries.[37] Cave experts Carol Hill and Paolo Forti noticed that the largest columns in Guadalupe Mountains caves, including Carlsbad Caverns (figure 8), *were aligned along ceiling joints and that a valley existed above the columns on the surface*:

> "Typically, the largest columns are aligned along ceiling joints, where the greatest amount of water is dripping into a cave. Hill (1978c) correlated the location of the most massive columns and stalagmites in Ogle Cave, New Mexico, with a valley on the surface overlying the cave. The joint along which the valley had developed is the same as that along which the massive travertine developed."[38]

Figure 9. Huge gypsum crystals from the Cave of the Swords, Naica, Mexico

The columns in Ogle Cave in the Guadalupe Mountains are as high as 20 m and are among the largest in North America.[39] For instance, above the Sequoia room in Ogle Cave is a topographic low: "Drainage is pilfered from this low down into the cave along major joints and minor cross joints". If the valley above Ogle Cave was overlaid with organic mud, it would add much more calcite to the speleothems as the water drained through the abundant joints. This could add another growth factor of 1.5 to 3 times in the soil $CO_{2(aq)}$, creating a unique condition for the rapid formation of columns.

This mud left by the floodwaters would also be the source of the sand and silt for the immense amount of loess during the Ice Age, after the climate dried at the end of the Ice Age. Mud or soil that remained in pockets above the caves after the Flood could have mostly blown away late in the Ice Age.

Thicker soil laced with organic matter, thriving vegetation, and much more moisture, all combined with an equable, mild climate early and midway through the Ice Age would *multiply* the amount of $Ca_{(aq)}^{2+}$ from the soil CO_2. As such, the growth rate could be 2 to 9 times that of today.

These conditions would explain why the many caves in the Guadalupe Mountains, for instance, including Carlsbad Caverns, have such large speleothems. It is well known that the climate is too dry today, winters too cold, and the soil and vegetation too sparse to result in much soil $CO_{2(aq)}$ and drip water calcium. That is why very few speleothems in the Guadalupe Mountains are growing today.[39] In fact, practically all the speleothems are considered relic or 'dead', and supposedly grew during wet 'glacial' periods over a period of about 4 million years.[16] It is doubtful that a uniformitarian ice age, one that the models say was much colder and drier than today, would provide the needed moisture. It is a contradiction that uniformitarian scientists have not faced. But the Guadalupe Mountains caves can be explained by the unique post-Flood Ice Age climate.

The period of rapid growth would stop by the end of the biblical Ice Age because the climate would change to be drier than it is today with much wind, colder winters, and drought. The vegetation and soil above the caves would mostly disappear with the wind.

Cave temperatures would increase growth rates early in the Ice Age

Moreover, the carbonate rock would be quite warm at the end of the Flood. This too would contribute to the growth of speleothems. Late in the Flood, runoff eroded hundreds and in some cases thousands of metres of sediment and rock from the continents.[40] Since temperatures increase downward, today about 30°C/1,000 m, the resulting carbonate rock would be very warm to hot right after the Flood with increasing temperatures downward. Since the growth rate of speleothems is proportional to cave temperatures, hot rock would increase growth rates early in the Ice Age. The rock would eventually cool by conduction from the surface and by cave ventilation, but the cooling would be retarded some by the high upward heat flow in the rock. High temperatures could cause speleothem growth to be about 1.5 to 3 times that of today for probably a hundred years or so after the Flood. Evidence for high cave temperatures is shown by the huge

Table 2. Postulated increase in speleothem growth rate early-to-mid Ice Age based on the main growth variables

Variable	Estimated enhanced growth over today
1) Equable temperature and more moisture	1.5 to 3 times
2) Thicker soil and more vegetation	1.5 to 3 times
3) High cave temperatures	1.5 to 3 times
4) Greater ventilation	1.5 to 3 times
5) Much faster drip rate	2 to 6 times
6) Thicker water film	1.5 to 3 times

gypsum crystals in the Cave of the Swords in Naica, Mexico.[41] These crystals are up to 12 m long, 4 m wide, and weigh 55 tones (figure 9). The estimated temperatures of growth, based on fluid inclusions, are 47° to 54°C (117° to 129°F).

Accepting a global Flood and an Ice Age following it greatly improves our understanding of Earth's history. In so doing we can find explanations for questions that uniformitarian scientists are unable to answer and solve challenges to our model posed by them.[42]

Cave CO_2 would aid speleothem growth

Another variable affecting the growth rate of speleothems is greater cave ventilation. Within the Flood paradigm, cave ventilation would be expected to be much stronger than it is today. This would be the case especially early in the Ice Age. It would be driven by the warm temperatures of the carbonate karst, which would continually vent to the cooler atmosphere by convection. Ventilation would not only lower the cave CO_2 but also the relative humidity for speleothem growth by evaporating water. Moreover, the year-round increased storminess and wind in at least the mid latitudes would also aid ventilation. Therefore, greater ventilation may have aided the growth of speleothems by more rapid degassing of CO_2 by something like 1.5 to 3 times that of today. A decrease in relative humidity could cause another 50% increase in speleothem growth if Carlsbad Caverns today can be used as an analog of what a little lower relative humidity can do.

Cave drip rate increased during the Ice Age

There is little doubt that the drip rate is a significant factor. Hill and Forti in the quote above noticed a correlation with columns below ceiling joints and copious dripping water.[38] Precipitation during the early-to-mid Ice Age would be much higher than today, practically everywhere unglaciated. This water highly charged with $CO_{2(aq)}$ would cause abundant drip water, and speleothems would be expected to grow much faster from just this variable, perhaps 2 to 6 times as fast.

Water film thickness increased during the Ice Age

The water film thickness on speleothems is a significant factor in their growth. The thicker the water film the greater the deposition of carbonate on speleothems. With the additional drip water, the film thickness dripping from the ceiling and stalactites onto stalagmites would increase. So, it would be significantly greater early-to-mid Ice Age than the assumed 0.1 mm a year, the value considered today. Additionally, the faster the drip rate the wider the stalagmite.[43] This would likely cause a decrease of the convex upward radius of curvature resulting in a thicker water film. These considerations may result in another 1.5 to 3 times the growth rate.

The net result

Combining all of the above leads us to conclude there is potential for tremendously rapid growth of speleothems in some caves and in some areas of the caves during the early-to-mid Ice Age. Some could have easily grown over 100 times the rate of today. The observation of a growth of 30 cm/yr for 3 years could be typical of some locations. It is not difficult to see how huge speleothems, especially the columns, could have grown in just 300 years following the Flood. Table 2 summarizes the variables that would enhance speleothem growth rate in the early-to-mid Ice Age.

The rate of growth would slow as the Ice Age progressed and probably reach close to today's slow growth rate or less by late Ice Age. Increasing storminess would result in greater ventilation, partly offsetting the other variables that would slow growth.

Conclusion

Rapid Flood uplift would result in much faulting of carbonates. Water draining through these fractures would become charged with sulfuric acid and cause rapid formation of the cave openings, as summarized in part 1. Five main variables determine the rate of speleothem growth, and these were discussed in part 2. In this part, I applied those variables from part 2 to the after-effects of the Flood and the rapid, post-Flood Ice Age to provide rough estimates of how each variable can result in faster speleogenesis. The Flood and the post-Flood Ice Age are keys to solving the time challenge of caves.

We have the potential of providing reasonable answers to many other time challenges presented by uniformitarian scientists. However, it takes much literature research; field work; and an understanding, as much as possible, of the geological and geophysical effects of the Flood and the post-Flood Ice Age.

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